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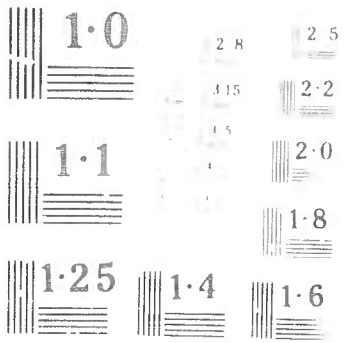
usaf ltr, 25 jan 1972



TEXAS INSTRUMENTS
INCORPORATED
SCIENCE SERVICES DIVISION

Air Force Technical Applications Center
VELA Seismological Center
Headquarters, USAF
Washington, D.C. 20333

Attention: Captain Carroll F. Lam

Subject: Fifth Quarterly Report Covering Period June 26, 1967 Through September 30, 1967.

AFTAC Project No.:	VT/6707
Project Title:	Large Array Signal and Noise Analysis
ARPA Order No.:	599
Name of Contractor:	Texas Instruments Incorporated
Date of Contract:	16 May 1966
Amount of Contract:	$1,083,696
Contract Number:	AF 33(657)-16678
Contract Expiration Date:	25 June 1968
Program Manager:	Frank H. Binder Area Code 214 238-3473

Gentlemen:

The extension of Contract AF 33(657)-16678 is still operating under a $250,000 letter contract. Approval of the one year extension in the amount of $490,023 is in progress.

Below are set forth the work progress against the major tasks remaining under this contract.

PUBLICATION OF SPECIAL REPORTS DEALING WITH WORK COMPLETED UNDER ORIGINAL CONTRACT

The following special reports have been published.

STATEMENT #2 UNCLASSIFIED

This document is subject to special export controls and each ansmittal to foreign governments or foreign nationals may be e only with prior approval of AFTAC - VELA Seismological Center Hq, USAF, Wash D C 20333

LASA Special Report No. 1 - A STUDY OF THE RELATIVE CAPABILITY OF LARGE AND SMALL SEISMIC ARRAYS FOR EVENT IDENTIFICATION.

LASA Special Report No. 2 - RESEARCH ON HIGH RESOLUTION FREQUENCY-WAVENUMBER SPECTRA.

LASA Special Report No. 5 - DETECTION OF DISCRETE ARRIVALS IN THE MANTLE P-WAVE NOISE.

LASA Special Report No. 8 - SHORT PERIOD SIGNAL SIMILARITY.

LASA Special Report No. 9 - LONG PERIOD SIGNAL SIMILARITY.

The following reports have been submitted to Captain Lam for approval and are in the final stages of publication.

LASA Special Report No. 3 - SUBARRAY PROCESSING.

LASA Special Report No. 6 - ANALYSIS OF SUBARRAY WAVENUMBER SPECTRA.

LASA Special Report No. 12-ANALYSIS OF LONG PERIOD NOISE.

LASA Special Report No. 13-NOISE COHERENCE AMONG SUBARRAYS.

The following reports have not yet been submitted to Captain Lam and are in various stages of typing and editing.

LASA Special Report No. 4 - SPACE AND TIME VARIABILITY OF THE LASA NOISE FIELD.

LASA Special Report No. 10-EQUALIZATION STUDIES.

LASA Special Report No. 11-RESOLUTION OF EVENTS.

LASA Special Report No. 14-WIENER NON-TIME STATIONARY PROCESSING.

CONTINUED SHORT PERIOD NOISE ANALYSIS

Three additional short period noise tapes have been received but have not yet been transferred into the Texas Instruments' system.

The continued short period noise analysis will consist of a study of locally generated noise and k-line spectral analysis of a few summer noise samples.

At the LASA the day noise is characteristically richer in higher (2 - 3cps) frequencies. This is almost certainly locally generated noise. A study will be undertaken to describe this locally generated noise as completely as possible. A few examples of this noise type are already in our short period library and these should be sufficient for this study. This portion of the short period noise study has not yet been clearly defined. Some visual analysis of the noise samples will be necessary before finalizing the study plans.

About three to five summer noise samples will be analyzed using interpolated k-line spectra. When considered with the previous results obtained in winter noise*, these should give an indication of seasonal variations in the major noise types.

LONG PERIOD NOISE ANALYSIS

The long period noise analysis has been broken down into four tasks.

- Stability of Noise Statistics

  Two signal extraction filters and one prediction filter have been designed from one noise sample and applied to a noise sample taken 6 hours later.

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* LASA Special Report No. 6, Analysis of Subarray Wavenumber Spectra

Most of processing has been completed and results are presently being analyzed.

- Further Study of the Noise Below .05 cps

  Previous analysis indicated that the noise below .05 cps was non-seismic. One long noise sample is presently in house which will be analyzed in detail in an attempt to determine the nature of the low frequency noise.

- Analysis of Summer Noise Samples

  The noise samples used on the previous contract covered the period of October to April. Several noise samples recorded during the summer months will be compared with those obtained for the winter samples. Analysis will consist of wavenumber spectral estimates, multiple coherence studies, and frequency power spectra.

- Study of the Composition of the Noise Field

  Attempts will be made to use the 3-component data to define the propagation modes of the noise as a function of frequency. Specific analysis techniques are presently being formulated.

SIGNAL DISSECTION

Two of the tasks relating to the signal dissection problem have been defined and initiated.

- P-Wave Extraction

  Techniques for obtaining a "cleaned-up" estimate of the P-wave arrival (i.e., a noise and scattered-energy free P-wave) are being evaluated. The adaptive processing scheme is

being tested and results are being compared with those from time-shift-and-sum techniques. The purpose of this processing is to reduce noise and other signal phases while passing P-wave phases.

- Summation Signal Processing

  A study of the theoretical ability of the summation to enhance various signal phases in the presence of ambient noise and interfering signals will be undertaken. This work will be based entirely on the summation wavenumber response of the array. Summation processing will also be evaluated using the same events used to evaluate the multichannel filtering techniques.

Other tasks relating to this problem have not yet been specifically outlined. It is anticipated that the tasks will be defined by the end of October and initiated immediately thereafter. These tasks will involve extensive use of the 3-component data.

HIGH RESOLUTION SPECTRA OF SHORT PERIOD SIGNALS

A. Work Completed

LASA Travel-Time Anomaly and Moveout Analysis

This analysis consists of a theoretical analysis of the moveout smoothing spectral window and a computation analysis of the travel-time residuals experienced at the Montana LASA. The theoretical analysis utilized a plane wave signal model and a "boxcar" smoothing function to study the combined effect of smoothing and move out on frequency domain processing of seismic arrays. Travel-time residuals were computed for 113 small regions of the earth using 384 recorded events.

Conclusions reached in this study were:

- The size of a region which can be corrected with the same travel-time residuals varies with

azimuth and epicentral distance.

- Both large travel-time residuals and moveout-smoothing spectral window effects make the use of the LASA E and F rings undesirable when computing high resolution wavenumber spectra.

The details of this analysis are contained in the LASA Special Scientific Report No. 15, Analysis of Travel-Time Anomalies and Moveout at LASA.

Study of Interative Techniques for the Solution of Frequency Domain Filter Sets

The following algorithms were studied with the objective of improving the speed and accuracy of computing high resolution wavenumber spectra.

- Steepest descent procedure
- Finite interation procedure
- Exact inverse procedure

In general, the exact inverse procedure was found to be the most efficient procedure. The application of this technique to iterative updating and smoothing filter sets was developed.

Details of this study are contained in LASA Special Scientific Report No. 16, Interative Techniques for the Solution of Frequency Domain Filter Sets.

B. Future Plans

Pilot Study to Investigate High Resolution Wavenumber Spectra Operational Parameters

This study has the following objectives:

- Determine the optimum transform gate overlap for locating single events in ambient seismic noise.
- Determine the optimum transform gate overlap for locating two simultaneous events.
- Select a set of reference sensors which yield good average location capability.
- Select a method of correcting filter sets for travel-time residuals during the computation of the wave-number spectra.
- Select a method for automatically computing the best estimate of an event epicenter.

Study of Adaptive Procedures for High Resolution Wave Number Spectra

Adaptive and iterative filter design procedures will be evaluated using the pilot study data ensemble. This evaluation will compare the location ability of single segment F - K spectra with those generated by a recursive formula for the inverse of a covariance matrix (a modification of the exact inverse procedure). If an adaptive procedure produces an improvement in the locatability of event epicenters, further studies will be made to optimize the procedure; and the final processing will incorporate the procedure.

Subarray Processing and Event Detection

An isotropic MCF with a high velocity pass band from 0.6 Hz to 1.6 Hz will be designed for each subarray. This processor will be compared with partial summations of subarray elements.

The on-line LASA detection scheme is indicated to be so effective that we did not seek new detection techniques. The LASA automatic event detector is a simple scheme where

the current peak energy in the band pass 0.95 Hz to 1.45 Hz is compared with the average energy in that band pass one minute previous. When this ratio is greater than a specified threshold (empirically chosen to be 5.82) an event is said to be present. To reduce the false detections due to non-teleseismic disturbances, one automatic event detector is attached to each subarray in the LASA E and F rings. If four of these detectors detect an event in a single 20 second period, a teleseismic event is said to be present. The false alarm rate of this detection scheme appears to be 2-3 events per day of continuous operation.

Details of the Automatic Event Detector can be found in a paper by H. W. Briscoe and P.L. Fleck titled, "A Real-Time Computing System for LASA" found in the Proceedings-Spring Joint Computer Conference, 1966. A study of event detection at LASA is presented in MIT Lincoln Laboratory Technical Note 1966-26 LASA On-Line Detection, and Signal-To-Noise Enhancement.

Final Processing

A data ensemble consisting of 39 events currently in TI library will be processed in a manner determined in the pilot study. Several types of composite events will be generated and processed to test the location ability of the high resolution F-K spectra technique in a complex signal environment. Other events, including several recorded by the E3 extended subarray, will also be processed and the results analyzed. Single subarray data will also be processed when available.

EVENT RESOLUTION

A new series of LASA slow mode tapes arrived in the latter part of August. Five of these tapes contained LP teleseismic events from four locations: Virgin Islands, Argentina, Sea of Okhotsk, and Kurile Islands. Magnetic tapes in a Texas Instruments' compatible format have been generated for three of these four events, with plots and tape dumps of the data now being studied. Transcription of the Kurile Islands recording has not been successful; after several attempts to reformat the SDL data reel it has been concluded that the source magnetic tape is faulty.

Work to date indicates that these signals contain many spikes, most of these spikes should be correctable. It has not yet been ascertained how much of this data will be usable.

Some compound long period events will be generated. These will be synthesised using real events compounded with various scaling factors and time shifts to simulate desired relative magnitudes and epicenter locations.

High resolution wavenumber spectra will be run on a single and some compounded long period events. These spectra should be useful in identifying phases masked by a strong, interfering event.

Separation of signal waveforms from overlapping signals will be attempted using theoretical velocity filters and measured statistics. The ability to orient horizontal components will be used in connection with the above techniques. For example, when trying to separate a small surface mode wave masked by a large one, taking the horizontal components transverse to the large event should give considerable rejection. These transverse traces could thus be used as input to velocity filtering schemes to further enhance the desired surface mode waves.

FINANCIAL STATUS

The financial status of the contract through August 1967 is summarized on the attached Cost Planning and Appraisal Chart.

Yours very truly,

TEXAS INSTRUMENTS INCORPORATED

Frank H. Binder

Frank H. Binder
Program Manager

FHB:se

Attachment

COST PLANNING & APPRAISAL CHART TI-10311

PROJECT NUMBER	CONTRACT NUMBER	PROGRAM DESCRIPTION
57060	AF 33(657)-16678	LASA EVALUAT

COLUMN CODE: 1. Monthly budget direct costs as projected in negotiated price.
2. Monthly actual direct cost
3. Cumulative budgeted direct dollars
4. Cumulative actual direct dollars
5. Variance budgeted vs. actual to
6. New estimate of total direct cost
7. Original estimate of total direct
8. Current estimate of direct costs

COST DATA

DIRECT COSTS

TASK/ITEM IDENTIFICATION	BUDGET EXPENSE MONTH: August 1967 Budget (1)	Actual (2)	EXPENDITURES TO DATE Budget (3)	Actual (4)	BUDGET VAR. (+) OVER (−) UNDER (5)	NEW ESTIMA TO COMPL (6)
LASA Evaluation						
Material	3,600	5,141	202,600	197,357	-5,243	124,8
Labor	7,925	7,527	117,925	122,576	+4,651	103,8
Other	0	253	4,000	4,022	+ 22	1,5
TIAC	150	150	80,000	82,444	+2,444	1,7
SUB TOTAL	11,675	13,071	404,525	406,399	+1,874	231,9

INDIRECT COSTS

TASK/ITEM IDENTIFICATION	MONTH August 1967 (2)	TO DATE	NEW ESTIMATE TO COMPLETE	TOTAL ESTIMATED INDIRECT COSTS ORIG. EST.	CURRENT EST.	VAR. (+) OV (−) UN
Material OH (6.5%)	1,625	13,649	7,295	17,500	20,944	+ 3,4
Labor OH (140.0%)	14,071	171,961	145,090	256,800	317,051	+ 60,2
Indirect Costs Subtotal	15,696	185,610	152,385	274,300	337,995	+ 63,6
Direct Costs Less TIAC Subtotal	12,921	323,955	230,252	484,894	554,207	+ 69,3
SUB TOTAL	28,617	509,565	382,637	759,194	892,202	+133,0
G & A (4.5%)	1,288	22,047	18,102	33,879	40,149	6,2
FEE	0	28,900	38,300	50,600	67,200	+ 16,6
TIAC	150	82,444	1,701	0	84,145	
TOTAL ESTIMATED COST AND FEE	30,055	642,956	440,740	843,673 (1)	1,083,	

CRIPTION
EVALUATION

DATE
5 October 196

ed vs. actual to date
total direct costs to complete
e of total direct costs
of direct costs

9. Varionce budget vs. new estimate
10. See instructions

R. NDER	NEW ESTIMATE TO COMPLETE	TOTAL ESTIMATED DIRECT EXPENDITURES ORIGINAL ESTIMATE	CURRENT ESTIMATE	VARIANCE (+) OVER (—) UNDER	% COMPL. TOWARD TECHNICAL OBJECTIVE
	6	7	8	9	10
					65
43	124,861	320,688	322,218	+ 1,530	
51	103,889	161,764	226,465	+64,701	
22	1,502	2,442	5,524	3,082	
44	1,701	0	84,145	+84,145	
74	231,953	484,894 (1)	638,352	+153,458 (1)	

SCHEDULE DATA

SYMBOL CODE:
- Start event (scheduled)
- Complete event (scheduled)
- Anticipated slippage
- Actual slippage
- Milestone

TIME: ☐ WEEKS ☐ MONTHS

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

DIRECT COSTS T.	VAR. (+) OVER (—) UNDER	CODE	ANALYSIS OF SIGNIFICANT PROJECT VARIANCES & PROBLEMS (COST - SCHEDULE - PERFORMANCE)
44	+ 3,444	1	Original estimates updated only to the extend of $250,000 letter contract.
51	+ 60,251		
95	+ 63,695	2	Includes adjustments for 1967 overhead rates.
07	+ 69,313		
02	+133,008		
49	6,270		
00	+ 16,600		
45	84,145		
96	+240,023		

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R&D
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
Texas Instruments Incorporated
Science Services Division
P.O. Box 5621, Dallas, Texas 75222

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP
—

3. REPORT TITLE
LARGE-ARRAY SIGNAL AND NOISE ANALYSIS
QUARTERLY REPORT NO. 5

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Quarterly No. 5 26 June 1967 through 30 September 1967

5. AUTHOR(S) *(Last name, first name, initial)*
Binder, Frank H.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
12 October 1967	10	1

8a. CONTRACT OR GRANT NO.
Contract No. AF 33(657)-16678

b. PROJECT NO.
AFTAC Project No. VT/6707

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
—

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

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11. SUPPLEMENTARY NOTES
ARPA Order No. 599

12. SPONSORING MILITARY ACTIVITY
Air Force Technical Applications Center
VELA Seismological Center
Headquarters, USAF, Washington, D.C.

13. ABSTRACT

This quarterly report is a summary of the progress under LASA Evaluation, Contract No. AF 33(657)-16678, during the period 26 June 1967 through 30 September 1967.

DD FORM 1 JAN 64 1473

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
LASA Evaluation Quarterly Report, 26 June 1967 - 30 September 1967						

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